Devonport Reinforced Soil Walls

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Summary At Devonport, in Tasmania, high strength polymer geogrids have been incorporated in pre-cast concrete panels to form reinforced soil walls. Constructed during mid 1994 the geogrid reinforced bridge abutments and approach road embankments are the largest of its kind in Australia, and the first of its kind in Tasmania. Some 1,500 square metres of wall, up to a maximum height of 7.6 metres were constructed, utilising panels of dimensions 2 metres high by 8 metres wide. Advantages over traditional "Reinforced Earth" systems included flexibility of casting panels, ease of construction utilising large panels and simplicity of geogrid to panel connection.

1. INTRODUCTION

The Victorian Bridge Complex, located over the Mersey River at Devonport, Tasmania, came about because of the construction of a new carriageway on the Bass Highway.

The vertical retaining walls support the roadway approaches, and retain soil adjacent to the roadways beneath two bridge structures. The walls vary in height from zero to 7.6m. Approximately 1,500 square metres of wall were constructed between July and September 1994. (See Fig. 1.)

The wall facing elements are 150mm thick, 8m wide and 2m high precast concrete panels. The concrete panels were cast on-site and steam cured at 700C for five hours. Geogrid was mechan-ically fixed to the panel steel reinforcement. The geogrids were fixed in one length, omitting the need for bodkin joints. (See Fig. 2).

2. TECHNICAL CONSIDERATIONS

2.1 Foundation Conditions

The site is located in the Mersey River valley. Geotechnical investigation identified a variable sub-surface profile at the site.

In the vicinity of the wall areas, fill materials comprising of mainly dense to very dense gravels, of 0.5 to 1.4m thickness, overlie natural residual soils consisting of stiff to hard highly plastic silty clays. Dolerite rock was intersected at depths varying from about 8m to 18m. Ground water was found at between 0.5 and 1.5m below ground surface.

It was concluded that a maximum allowable bearing pressure of 205 kPa, with a factor of safety of 3, was appropriate for the proposed walls with reinforced soil block widths of up to 5.8m.

2.2 Design

The bridge abutment superstructure loads are supported on 450mm diameter cast in place concrete columns extending through the wall fills, formed prior to the start of wall constructions. The columns are located at spacings of between 3.0m and 3.8m. The columns are supported on driven concrete piles that will be terminated near the existing ground level. The centreline of the columns for all bridge abutments are located 0.65m behind the wall facing panels. A compressible material was wrapped around the abutment columns to prevent longitudinal bridge loads being transferred into the abutment walls. (See Fig. 3).

The abutment wall of the Railway Bridge was designed to withstand impact loads resulting from a train collision with the bridge pier. The abutment wall was therefore designed for the following horizontal tension forces applied at the level of the underside of run-on slab:

- 400 kN parallel to wall
- 350 kN square to wall

The width of the run-on slab is about 16m.

Fine to coarse gravelly sand was chosen for use as wall fill within the reinforced soil block. Silty clay was proposed for use as retained backfill in the body of the embankment.

The retaining wall structures were designed utilising a tie-back wedge method of analysis and assuming an active Rankine state of pressure and a trapezoidal distribution of stresses from the retained backfill. This method is referred to as the

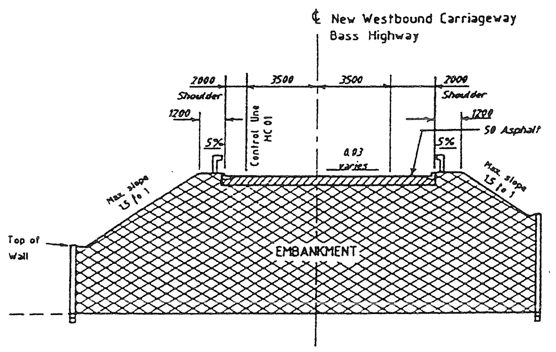

Figure 1. Embankment cross-section (typical).

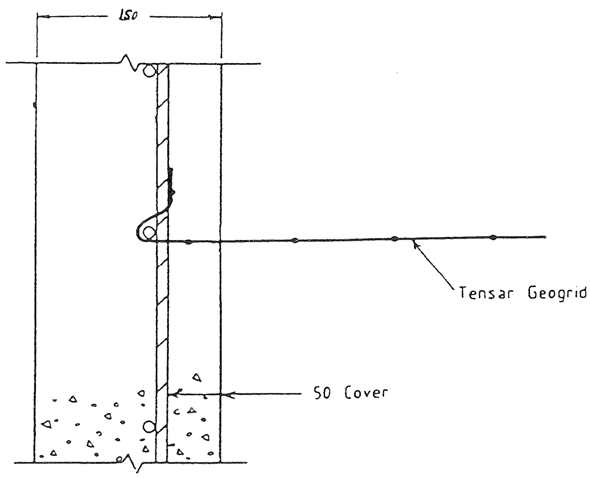

Figure 2. Tensar - wall connection detail.

'General Method' in the Draft Australian Standard for Reinforced Soils.

In addition to the above analysis, internal stability checks using the 'Tied-Back' Wedge' method of analysis were made for each abutment wall design section.

The analysis indicated that the allowable tensile strength of the geogrid rather than the pull-out resistance within the wall fill, was critical for all sections checked.

The designs called for vertical spacings of geogrids ranging from 0.4m to 0.6m extending some 5.7m behind the face of the wall.

Global Stability Analyses were undertaken at various locations along the wall. The global stability checks were made for slip circles passing through and beneath the geogrid reinforced zone of the wall. The critical slip circles passed beneath the reinforced soil block, with adequate minimum factors of safety of 1.3.

A surcharge traffic load of 20 kPa was used for these analyses in accordance with the AUSTROADS Bridge Design Code, Section 2.11.3.

2.3 Geogrid Reinforcement

The reinforcement used in the construction of these walls was Tensar SR110, S80RE and S55RE geogrids. The properties of these geogrids are shown in Table 1.

2.4 Levelling Pads for Facing Panels

All walls were founded with minimum embedment depths of 0.2m below existing ground levels. Concrete levelling pads for support of facing panels were located below the minimum embedment depth.

The dimensions of the concrete levelling pads located beneath the facing panels were 300mm wide by 150mm thick. The levelling pads were constructed of unreinforced concrete with a minimum strength of F'_c = 20 MPa. Subgrade preparation, including excavation and removal of unsuitable material and soft areas and replacement with approved select fill was carried out.

2.5 Geogrid Location Adjacent to Abutment Columns

It was necessary to locate geogrids around the vertical columns that extend through the wall fills at the bridge abutments. Cutting of the geogrids was carried out with care to ensure a close fit around the columns and attached to the wall facing panels in these areas. Geogrids were installed in front of the columns, and attached to the wall facing panels in these areas.

2.6 Overlapping Geogrid Areas

In the corner areas of the abutments and abutment wingwalls, there was overlapping of geogrids in plan area. In these locations a minimum vertical clearance of 75mm was provided to allow adequate geogrid-wall fill interaction to develop for each separate geogrid.

Table 1. Geogrid properties.

Geogrid type	Q.C. Strength (kN/m)	Creep Limited Strength (kN/m) × 10°C	Polymer	Weight (kg/m²)	Roll Dimensions (m)
S55RE	55	23	H.D.P.E.	0.4	50 × 1.3
S80RE	80	33	H.D.P.E.	0.6	50 × 1.3
SR110	110	45	H.D.P.E.	1.1	30 × 1.0

* Determined by the application of standard extrapolation techniques to creep data obtained in accordance with BS 6906 Part 5 for a strain not exceeding 10% in 120 years.

2.7 Adjusting Geogrid to Fit Concrete Panels

It was acceptable to vary the vertical location of the geogrids by up to 100mm to suit concrete panel joints.

3. CONSTRUCTION ASPECTS

3.1 Concrete Panels

The concrete panels were pre-cast on site using steam curing at 700C over 5 hours to achieve rapid set. No negative effects occurred to the geogrid due to elevated temperatures.

Large panel dimensions, 2m high by 8m wide were adopted to ensure ease of construction. The contractor had large cranes available on site to erect bridge beams, so there was no problem in lifting large pre-cast concrete panels.

The erection of panels was carried out with reference to Tensar guidelines, "Construction Sequence 7". These guidelines recommend a 1 in 40 layback of each panel. This equates to 50mm for a 2m high panel. However, initially ground level panels were laid back at 20mm, or 1 in 100. After backfilling vertical movements of up to 20mm were observed at the top of the panels. Panel lay-back was then increased to 30mm.

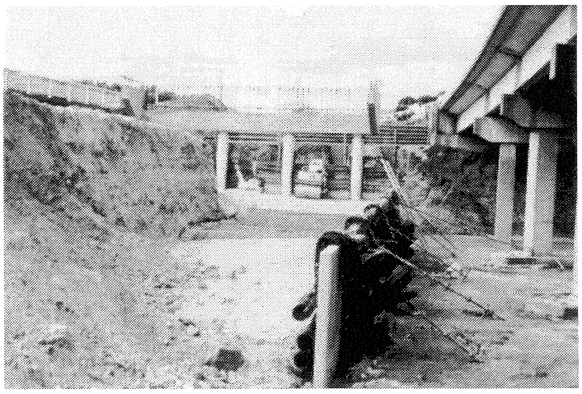

Figure 3. Abutments during backfilling.

3.2 Propping of Concrete Panels

Panels erected at ground level were propped with standard tilt-up props. Timber members were then fixed to the outside of these panels to act as temporary formwork for the upper panels to bear against. (See Fig. 4).

3.3 Performance

Construction proceeded smoothly and both the contractor and client were satisfied with progress. Practical completion was given on November 1994. Formal survey of the walls has not been undertaken, however, visual inspections indicate that performance is within expectations. As would be expected for a structure with a 120 year design life, no distress or movements of the walls have been found.

4. ECONOMIC BENEFIT

Initially these retaining wall structures were designed as a "Reinforced Earth" (RE) system by the Department of Transport and Works. The contractor chose the geogrid alternative for the following reasons:

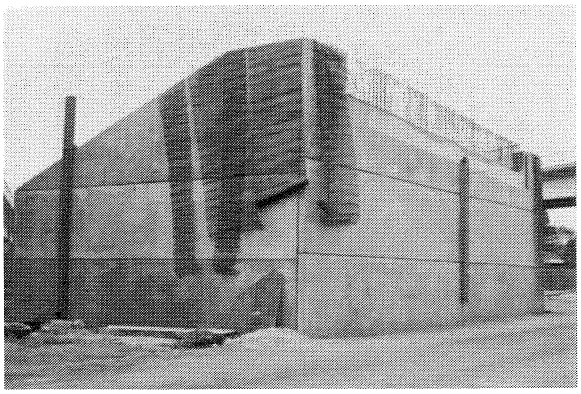

Figure 4. Erected panels.
(Note Timber Formwork).

1. Flexibility - The contractor cast his own facing panels instead of purchasing concrete panels from the RE supplier.

2. Ease of Construction - Large panel size suited the contractor due to the availability of heavy lifting cranes on-site. The larger panel size also minimises local differential movement between panels, which can be a problem when using smaller panels such as used with the RE system.

3. Simplicity - Geogrid is simple to connect to concrete panels, by mechanically fixing the grid to the steel reinforcement at the casting stage.

5. CONCLUSION

So, to conclude, the concept of reinforced soil has been used in an innovative way to form 7.6m high road embankment walls. In this case study the concept of reinforced soil was adapted for use in very large concrete facing panels, 2m high and 8m wide, and incorporated the use of high strength polymer geogrid reinforcement. This system resulted in construction efficiencies and economic benefits. Completed in September 1994 the walls have performed within expectations to date.

6. ACKNOWLEDGMENT

The author wishes to acknowledge the contribution of Mr. Ivan Haustorfer, Senior Engineer at Golder Associates, Melbourne, Australia.

7. REFERENCES

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